

Development of Thermal and Water Management System for PEM Fuel Cells

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Crystal Gateway Marriot
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Honeywell

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Agenda

- Overview
- Program Status
- Objectives
- Approach
- Test Results Summary
- Milestones
- Go-forward Plan

Overview

Timeline

- Project start FY03
- Program stopped FY05/FY06
- PO end date April 2009
- 70% complete

Budget

- Total project funding
 - DOE share - 3,250K
 - Honeywell - \$812K
- DOE funding in FY 2003/04
 - \$1,530K
- DOE funding in FY07
 - \$372K
- DOE funding for FY08
 - \$400K

Barriers

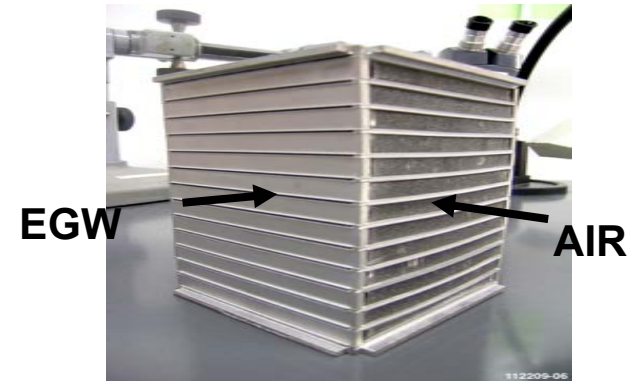
- Performance of select full scale humidification system
- Thermal performance of advance radiators to meet fuel cell cooling requirements

Partners

- US Department of Energy
- Argonne National Lab
- FreedomCAR Tech Team

Thermal & Water Management Program Status

- DOE funding was stopped for FY 05/06
- Water management task was selected for FY 07 due to limited funding followed by thermal management
- Accomplishments during FY2003/04
 - Develop humidification and cooling system for 80 kW fuel cell for transportation
 - Performed system concept analysis
 - Radiator trade studies showed potential for improvements in current technology
 - Microchannel and advance louver heat exchanger were down selected
 - Preliminary Design & analysis completed
 - Short stack microchannel heat exchanger was fabricated



Objectives for FY 2007/2008

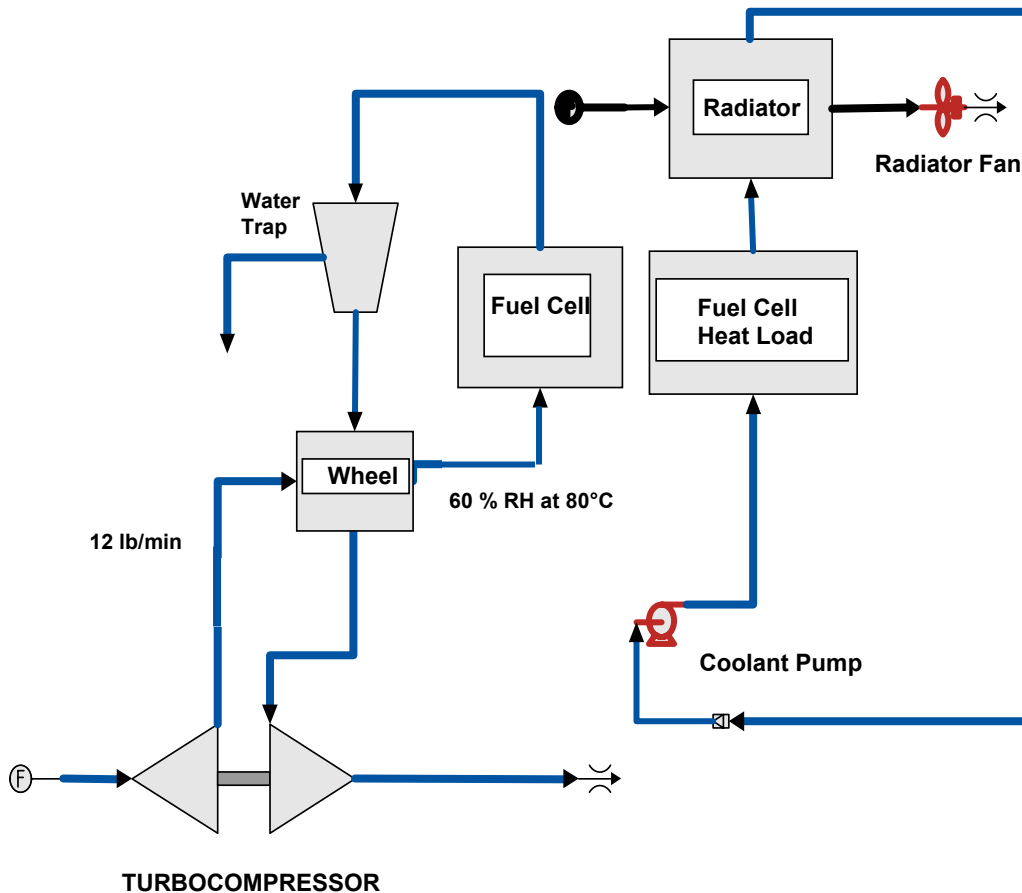
- Validate performance of full scale humidification devices sized for 80 kW fuel cell
 - Install, hook-up and checkout test stand
 - Test Emprise enthalpy wheel
 - Test Perma Pure membrane module
- To improve PEM fuel cell performance and life, the humidity of inlet air stream should be maintained at a high level (currently 60%)
- Design a full size radiator to meet the 80 kW fuel cell cooling requirements

Approach

- The inlet air to the PEM fuel cell stack should have a minimum humidity of 60% (at 80 °C) for performance and increased life
- Two humidification systems were down-selected for the fuel cells application
 - Enthalpy Wheel (ceramic honeycomb) rotates while adsorb moisture from fuel cell outlet air and transfer (de-sorb) it to the inlet air
 - The Nafion membrane transfer moisture from one side of the air stream to the other side. The membrane has upper temperature limit which require pre-cooler in the inlet air stream
- Small scale systems met the requirements
- Full scale system testing is 80% complete
 - Enthalpy wheel seal leakage of up to 18% was observed at high operating pressures
 - Membrane module performance degraded at lower air flow rate

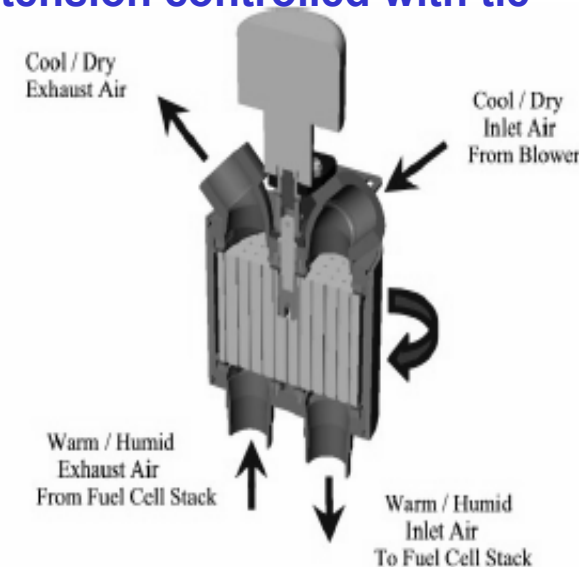
System Approach I (Enthalpy Wheel)

Test Schematic



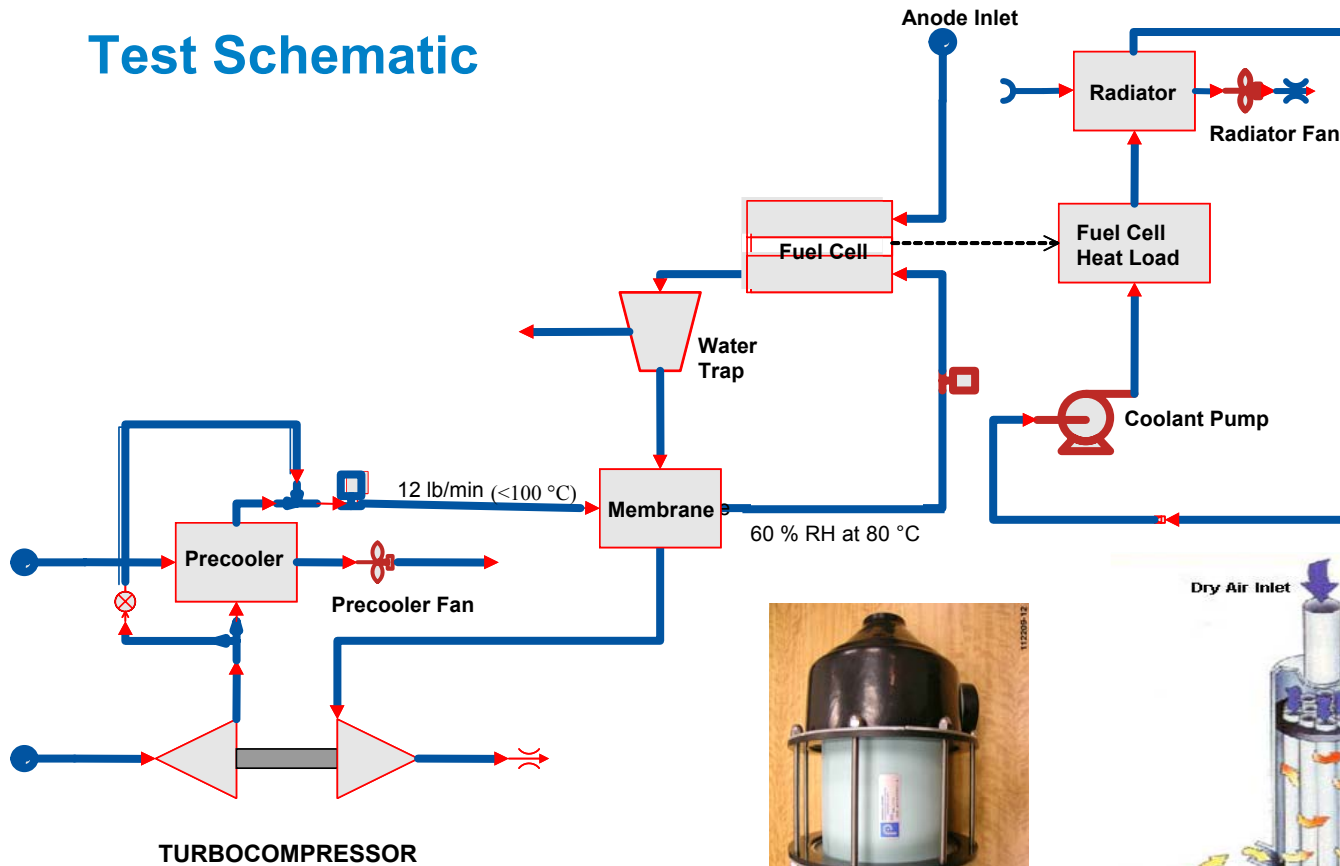
Enthalpy Wheel By Emprise

- Water adsorbed and de-sorbed in a rotating wheel
- Power: < 100W
- **Leakage < 1% process flow**
- 8" Ø, 6" length wheel
- Vol: 17l cu in.; Wt: 17 kg
- Anodized Al construction
- Seal tension controlled with tie rods



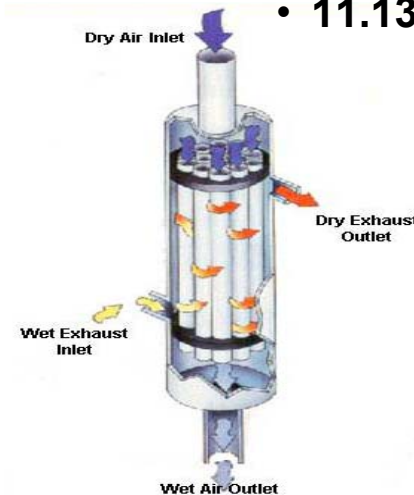
System Approach II (Membrane Module)

Test Schematic

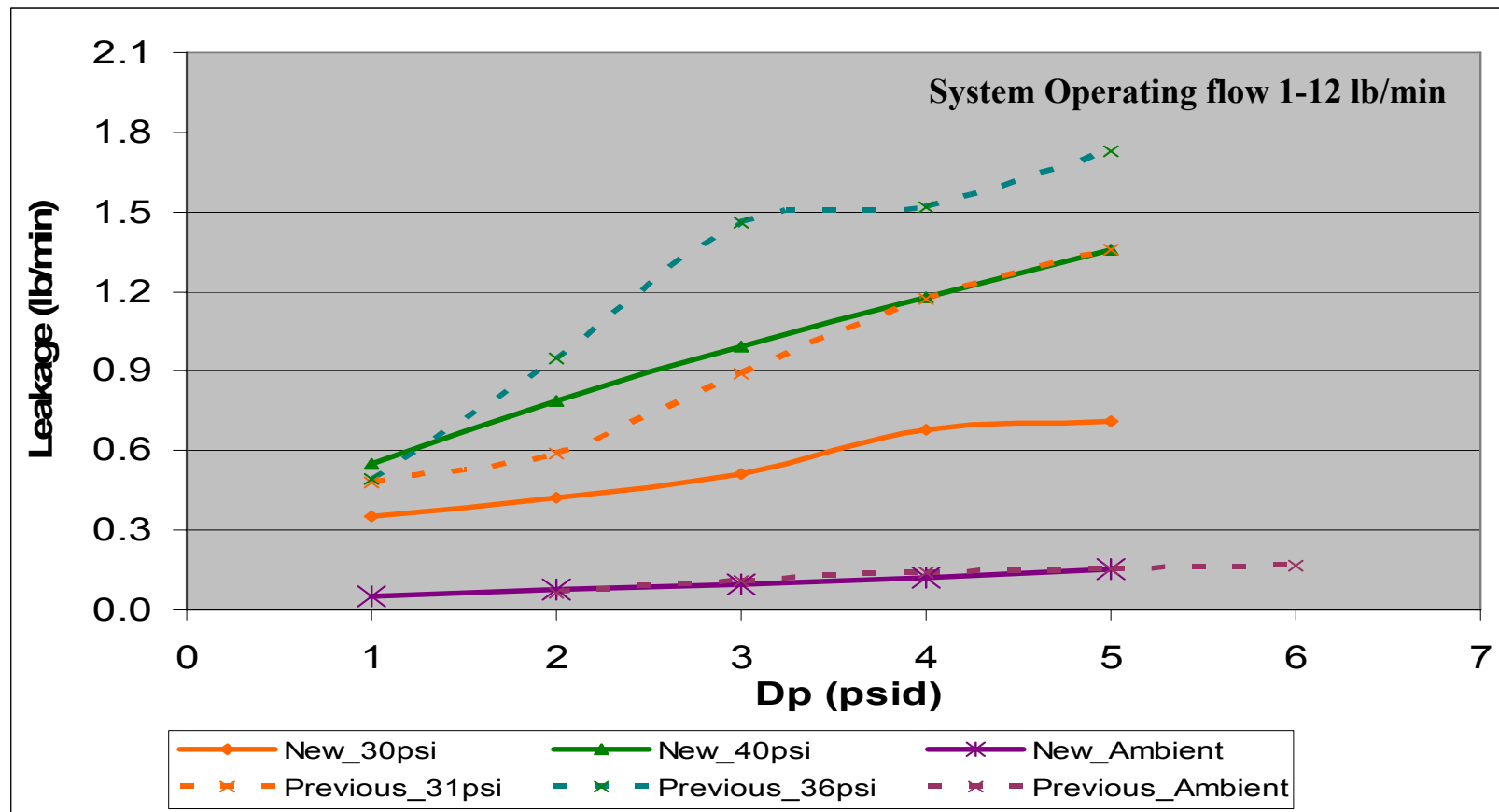


Membrane dryer by Perma Pure

- Membrane selectively allow water to pass through
- Performance sensitive to temp.
- 6" Ø, 10" length cartridge
- 7000 fibers 0.045" OD
- 11.13 in² Nafion

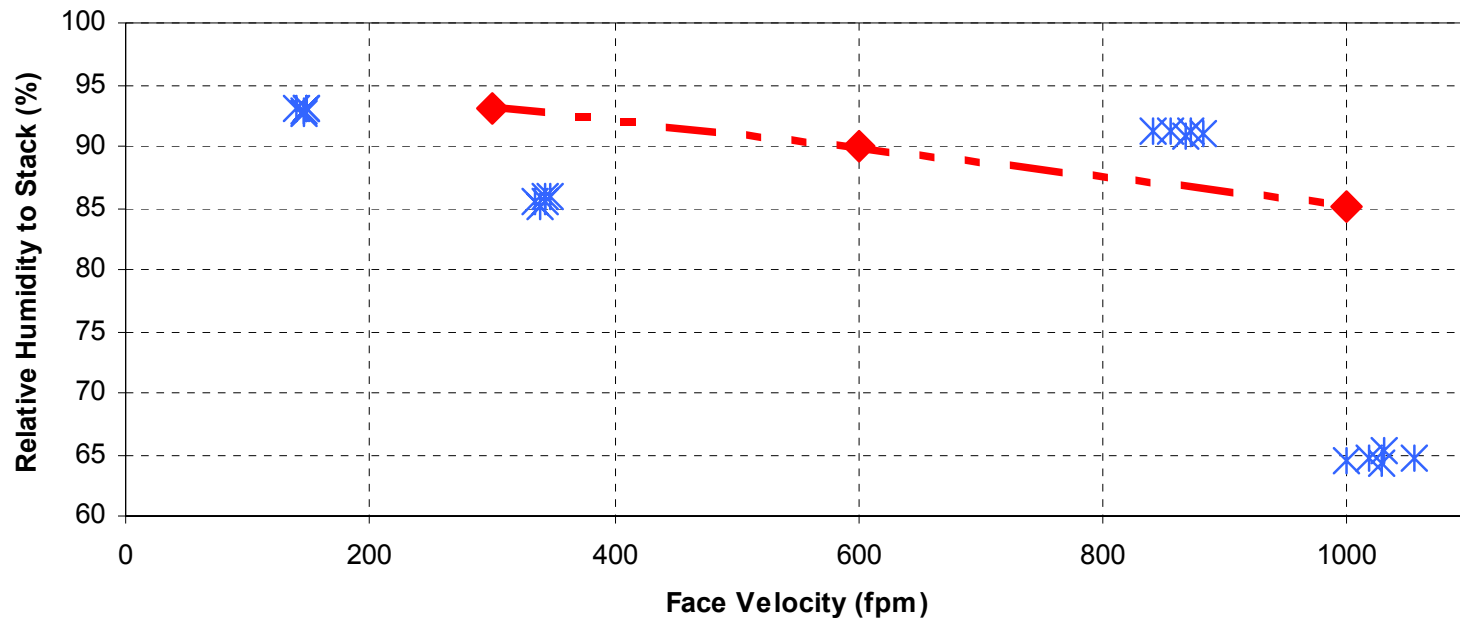


Enthalpy Wheel Seal Leakage



High Seal Leakage at higher operating pressures

Enthalpy Wheel: Humidification

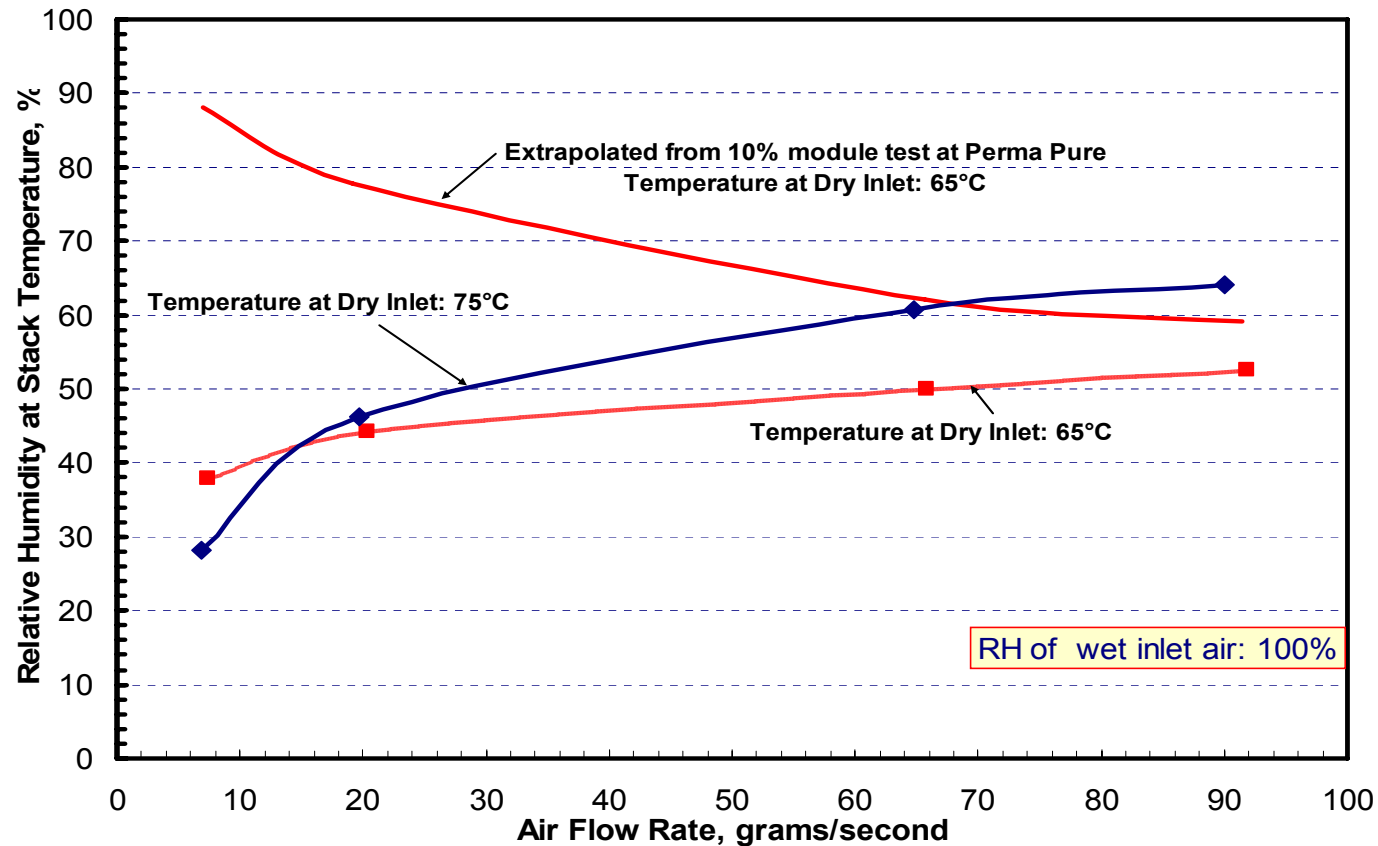


◆ 10% Sub scaled data by supplier

✱ Full-Scale 45 rpm

High Seal Leakage result in low performance

Membrane: Humidification

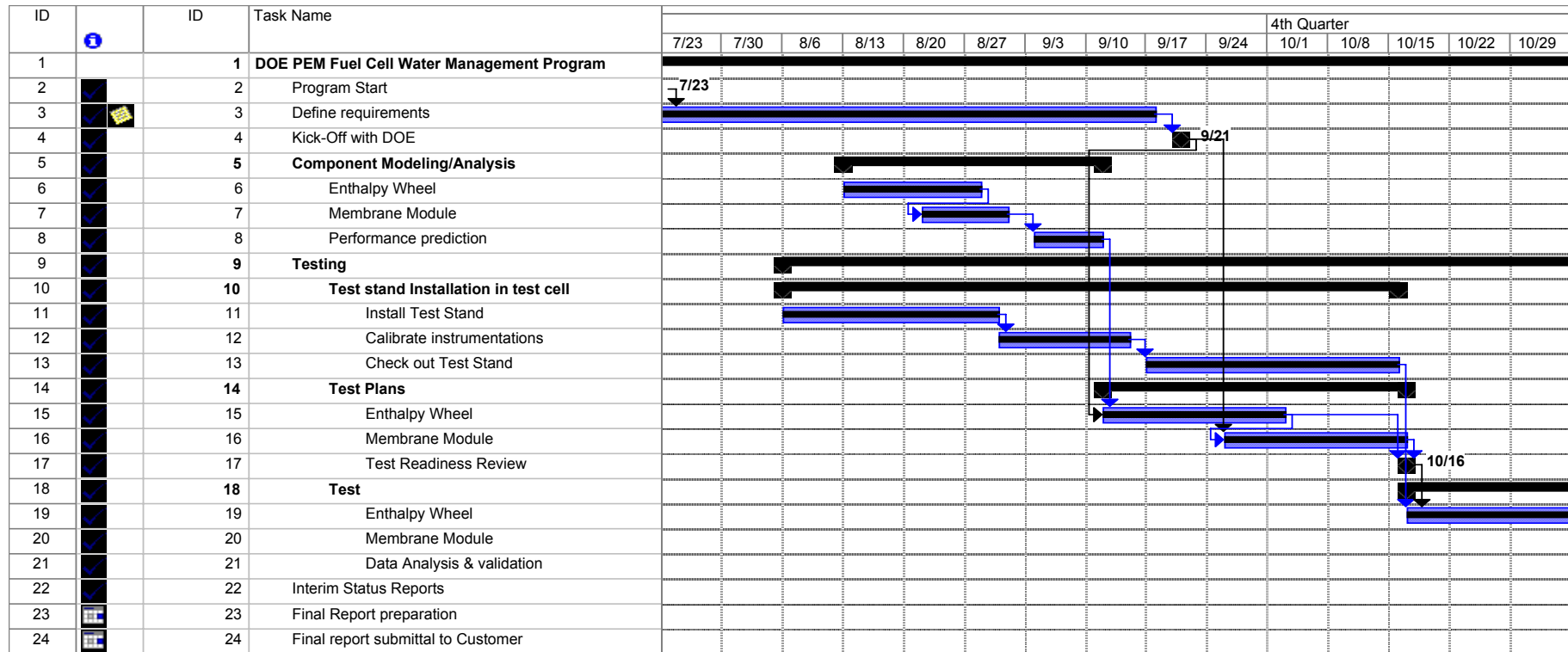


Relative Humidity less than 60% at low face velocity

Test Results Summary

- Enthalpy wheel showed leakage up to 15% across the seal at higher operating flows (pressures)
- Enthalpy wheel humidification data was scattered due to seal leakage
- Membrane module met humidity requirements at high flow rate, at low flow rate the performance degrades due to air bypassing the membrane bundle
- Honeywell is working with manufacturer to improve the performance of the humidification devices
 - Emprise have made some modification which resulted in reduced leakage
 - Plan to test half scale membrane module to validate saturated air bypassing

FY07/08 Schedule and Major Milestones



Water Management program kickoff

Requirements definition

Test system set-up

Test Readiness Review (TRR)

Enthalpy wheel testing

Membrane module testing

Thermal Management program kickoff

7/23/07

9/21/07

10/2/07

10/16/07

11/15/07

12/17/07

3/27/08

Thermal Management Go-Forward Plan

FY 2008

- Complete re-testing of the humidification devices
- Re-visit radiator trade study
- Evaluate performance of advanced radiator technologies
 - Radiator size & weight optimization
 - Parasitic power consumption
 - Manufacturability and cost
- Verify 80 kW PEM Fuel Cell Thermal Management CTQ's
- Radiator Fan and coolant pump
 - Power Optimization
 - Drag needs to be evaluated

FY 2009

- Design, built, and test full scale radiator for select technology
- Validate design and demonstrate performance
- System integration of thermal & water management system